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Occupational Health in Ontario

Volume 8, Number 4, Fall 1987,

Silicosis Incidence in Southern Ontario

Thoron Daughter Concentrations in Three Non-Uranium Mines in Ontario

Video Display Terminals – Do They Emit Dangerous Levels of Radiation?

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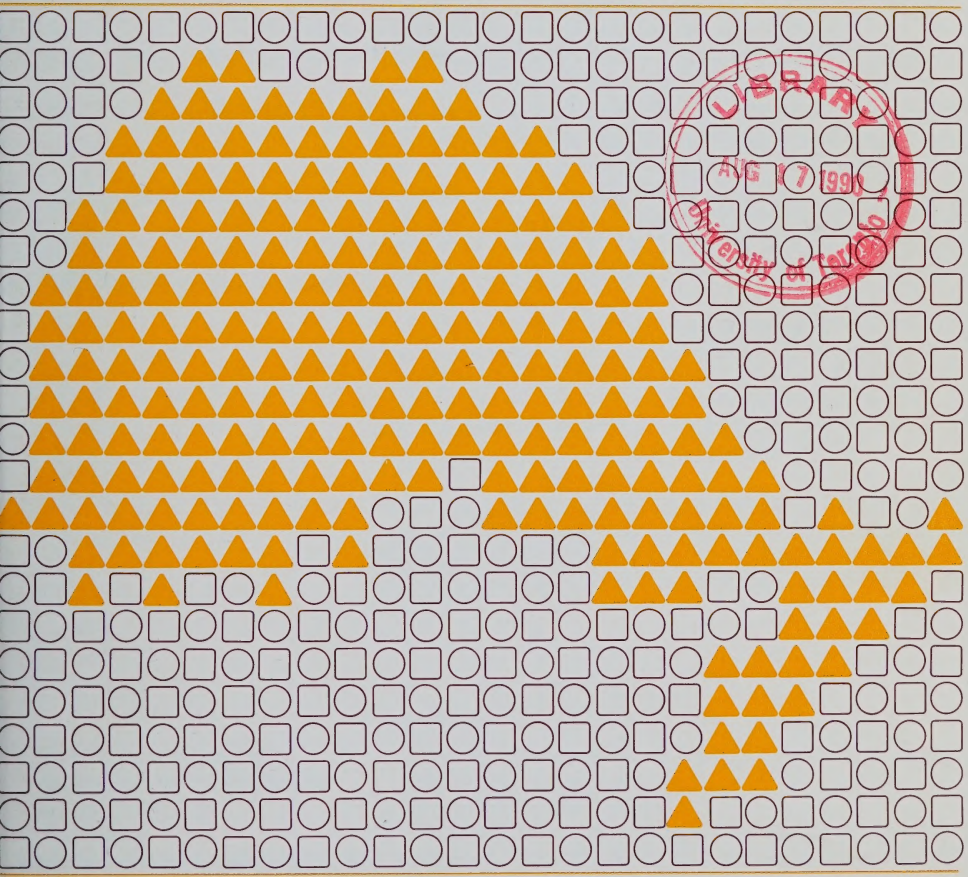

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Occupational Health in Ontario

Volume 8, Number 4, Fall 1987

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Waldemar M. Maehle, M.D.

Silicosis Incidence in Southern Ontario

Summary

This paper reviews the incidence of silicosis in Ontario from 1980 through 1986, with particular attention to the 'mini epidemic' reported for 1983/84 and 1984/85. These 'statistical bumps' are re-examined in the light of the changed system of reporting since 1983, when the ILO protocol was introduced province-wide.

The apparently elevated count of new cases was due to divergent film interpretations under the newly introduced system of reporting.

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Introduction

Silicosis is the lungs' reaction to inhaled quartz dust. If the crystalline silicon dioxide particles are small enough to penetrate to the alveoli, they cause the formation of discrete nodulations within the lung tissue. On the chest X-ray these nodules appear as opacities of variable size and profusion.

They may either remain discrete or may conglomerate into larger groupings, which can, in turn, lead to varying degrees of distortion of normal anatomy of the lungs. Depending on severity, this may cause corresponding respiratory dysfunction. Although nodulations may be widespread, they usually remain separated by healthy lung tissue for a long time and cause neither breathing impairment nor lessening of work capacity. Thus, the chest X-ray is the usual method of confirming their presence. Examining a piece of lung tissue under the microscope is only very rarely necessary to establish a diagnosis.

In Ontario, silica is one of the substances designated under regulations made under the *Occupational Health and Safety Act.*[1]

These regulations make it mandatory for workers exposed to silica to participate in surveillance programs such as are carried out by the Occupational Health Branch of the Ministry of Labour.

Industries under surveillance include the following:

Mining
Foundries
Ceramics
Stone Cutting
Quarrying
Tunnelling
Production of Abrasives
Sandblasting
Refractories

In 1985/86, 25,998 workers in silica exposure were examined by the Medical Service Chest Clinics of the Occupational Health Branch of the Ministry of Labour

in both southern and Northern Ontario.[2] Nineteen workers were found to have newly developed radiographically suspected silicosis. Comparison with previous years[3] reveals the following (Table 1):

Table 1

Years	# Cases of Silicosis Reported
1985/86	19
1984/85	42
1983/84	28
1982/83	11
1981/82	15
1980/81	18

Looking at these numbers a 'statistical bump' is evident for the years 1983/84 and 1984/85.

In this context two facts must be borne in mind:

1. There was a change in data base in 1983.
   In 1983 the northern chest clinics were transferred from the Ministry of Health to the Ministry of Labour. Thus, the statistics for the years 1983, 1984 and 1985 contain cases that previously would have been reported by the Ministry of Health. Subtracting the number of cases of silicosis reported by the northern chest clinics from the totals above produces this tally:

Table 2

Years	# Cases of Silicosis Reported
1985/86	9
1984/85	27
1983/84	22
1982/83	11
1981/82	15
1980/81	18

2. There was a change in the format of reports in 1983.
   In September 1983 the Medical Service Chest Clinic began to report all chest X-rays according to the ILO 1980 protocol.

Despite this adjustment, the number of cases of silicosis reported for the years 1983/84 and 1984/85 continues to be conspicuously elevated in comparison to findings reported during previous years.

Sudden statistical jumps of this magnitude should raise questions with respect to the efficacy of existing dust control measures.

Because of these changes, it was decided to re-read and re-code all cases of silicosis reported since 1980.

Methodology

Two of the four original readers and a third experienced reader from outside the Ministry of Labour re-read all the films with diagnosis of silicosis that were still available.

The findings are summarized in Table 3. The word 'consensus' indicates perfect agreement of all three readers.

The greatest disagreement between the readers (shaded area of Column 5) continues to exist with respect to findings for the years 1983/84 and 1984/85, when the ILO protocol was introduced.

The disagreement centres around the question: – At what point is the diagnosis of silicosis made?

Table 3

Years	# of New Cases of Silicosis Reported by the Southern Cl.	Population at Risk	# of Films Available for Review	Consensus
1985/86	9	13,282	8	8/8
1984/85	27	12,427	20	12/20
1983/84	22	11,538	21	8/21
1982/83	11	11,087	11	8/11
1981/82	15	12,275	14	13/14
1980/81	18	7,125	17	16/17

Discussion

The results suggested that the apparently elevated incidence of silicosis in the southern clinic was due to divergent film interpretations, caused by the introduction of a different form of classifying chest X-rays from a system that was used previously. The International Labour Office (ILO) system has undergone several changes since its introduction in 1958. The 1980 modification was introduced for routine use by the chest clinics in Ontario in September 1983.

The ILO Classification was developed to help in coding X-ray appearances of the pneumoconioses in a way that allows comparison between readings done under different jurisdictions.

The new approach facilitates statistical and epidemiological investigations of exposed populatons, but both

over-reading and under-reading of X-ray markings may affect their interpretation.[4]

Normally, a reader using the ILO Classification is given no information with respect to previous medical history, previous dust exposure, previous chest X-rays or current working conditions. In spite of long familiarity with the appearances of pneumoconioses, as well as with the standard reference films, inter-observer differences are a known occurrence.[5]

The ILO 1980 Classification consists of a written text, a set of standard reference radiographs and a series of explanatory notes. The latter include a 'critique' of the standard films by a panel of internationally recognized experts. While the Classification 'does not define pathological entities, does not take into account working capacity, does not imply legal definitions of pneumoconiosis for compensation purposes, nor set or imply a level at which compensation is payable,'[5] it is, nevertheless, true that the mere presence of a certain level of profusion of regular or irregular (radiological) opacities in an individual with a history of occupational exposure to fibrogenic dusts carries with it certain definite medico-legal implications.

The latter are borne out of the fact that profusion of radiological opacities can be linked to

a) cumulative dust exposures, and
b) the dust content of post-mortem lungs.

Usually, a diagnosis of pneumoconiosis is considered when chest radiographs show a 1/1 profusion of small opacities.

In this context it is important to remember that 'the 1980 Classification requires that the profusion of small opacities should be determined by comparison with the standard radiographs and by integrating the profusion seen over the affected zones of the lungs.'[5]

Furthermore, 'the standard radiographs take precedence over the text for definitions.'[5]

Some confusion originates in knowing that 'the standard films are typical of appearances classifiable as *near the middle* of the four main categories defined by the scheme.'[5]

The very term 'Mid-Category Standard' implies that a radiograph showing a slightly lower *or* slightly higher profusion of opacities than seen on the standard film could still be classified as belonging to the category in question. However, how much leeway *does* the scheme have? What are the 'Margins of Tolerance' of the system?

There appear to be two ways of interpreting the ILO scheme:

1) a rigidly pictorial one: for instance,
   In the United States, under the Rules and Regulations of the Federal Mine Safety and Health Act[6] the ILO Classification is incorporated into the said regulations and used for:
   a) legal definition of pneumoconiosis, and
   b) instigating removal from work where a miner's chest X-ray shows evidence of category 1, 2, or 3 of simple or complicated pneumoconiosis.

These provisions are made in direct contravention of the object of the classification, which is to code X-ray appearances of the pneumoconioses in such a reproducible way as to allow making comparisons between readers operating in different jursidictions. Also, the rules and regulations refer to readings by the U.S. Public Health Service Consultant Panel of 'B' Readers. In order to qualify as a 'B' reader one must complete an examination developed under contract with Johns Hopkins University and graded by the contractor. To pass the proficiency examination, films must be coded using rigid pictorial ILO criteria. To qualify as showing a 1/1 profusion, a radiograph must correspond exactly to whatever is seen on the Standard 1/1 film. This rule applies to both profusion of opacities and extent of lung involvement. (Four zones for any 1/1 category.) Anything less than that that is seen on the standard film is coded as less than 1/1.

2) The heretofore Ontario way, in which a *definitely* abnormal film (one where the 0 category was not seriously considered), was automatically coded 1/1 regardless of the fact that it may have fallen somewhat short of the mid-category standard.

This approach, however, appears to have inflated the annual statistics. Indeed, it could be argued with some conviction that the Ontario attitude amounted to relying on written definitions rather than on the *standard films*.

It seems that, not withstanding long familiarity of all readers with the standard films, a certain vacillation occurs when the readers are asked to report *all* films according to the ILO protocol. The vacillation is between what the book postulates and one's well established conditioned reflexes. This uncertainty results in some overcall. The uncertainty appears to have rectified

itself with the passage of time, and the agreement between all three readers was unanimous for all cases reported for the year 1985/86.

This problem would not have arisen if there were standard radiographs available that define the three boundaries between the four main categories. The existence of such 'boundary' standards would be of immense help in distinguishing between categories 0/1, 1/0 and 1/1/.

International trials that preceded the selection of the 1980 standard films identified some radiographs that might be regarded as such boundary standards. It is to be hoped that work will continue in that direction.[5]

This little exercise emphasizes the need to ensure that all readers interpret the code as uniformly as possible.

No international reporting system can be truly regarded as being better than others unless its users adhere to its methods and can demonstrate a reading level regarded as standard in other jurisdictions.

The Canadian Pneumoconiosis Panel[7] was developed to fill this particular need.

Résumé

Cet article étudie la fréquence des cas de silicose relevés en Ontario entre 1980 et 1986, et en particulier la 'mini épidémie' constatée entre 1983 et 1985. Ces poussées statistiques sont revues à la lumière du nouveau système de déclaration introduit en 1983, lorsque le protocole de l'ILO a été adopté pour l'ensemble de la province.

Le chiffre à première vue élevé de nouveaux cas s'explique par une interprétation différente des données en vertu de nouveau système de déclaration.

Acknowledgements

The author would like to thank Dr. J. Chan and Dr. D. Muir for reviewing the chest X-rays, and Dr. J. Roos for reviewing the manuscript.

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Subchapter C – Medical Care and Examinations. Part 37 – Specifications for Medical Examinations of Underground Coal Mines

Subpart – Chest Roentgenographic Examinations.

[7]Occupational Health in Ontario, Vol. 5, Number 3, July 1984; pp. 119-121.

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E.G. Baker
D.A. Marsden, Ph.D.

Thoron Daughter Concentrations in Three Non-Uranium Mines in Ontario

Summary

Some non-uranium mines may have uranium and thorium present in the ore. If all the airborne alpha radiation measured is ascribed to radon daughters without any account of thoron daughters, then the exposure of miners to radon daughters is overestimated and may violate existing legislation.

This paper reports on an investigation into the presence of thoron and thoron daughters in three non-uranium mines. The theory and the method of measurement used are presented. The results obtained show that thoron is not a significant problem in the mines investigated.

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Introduction

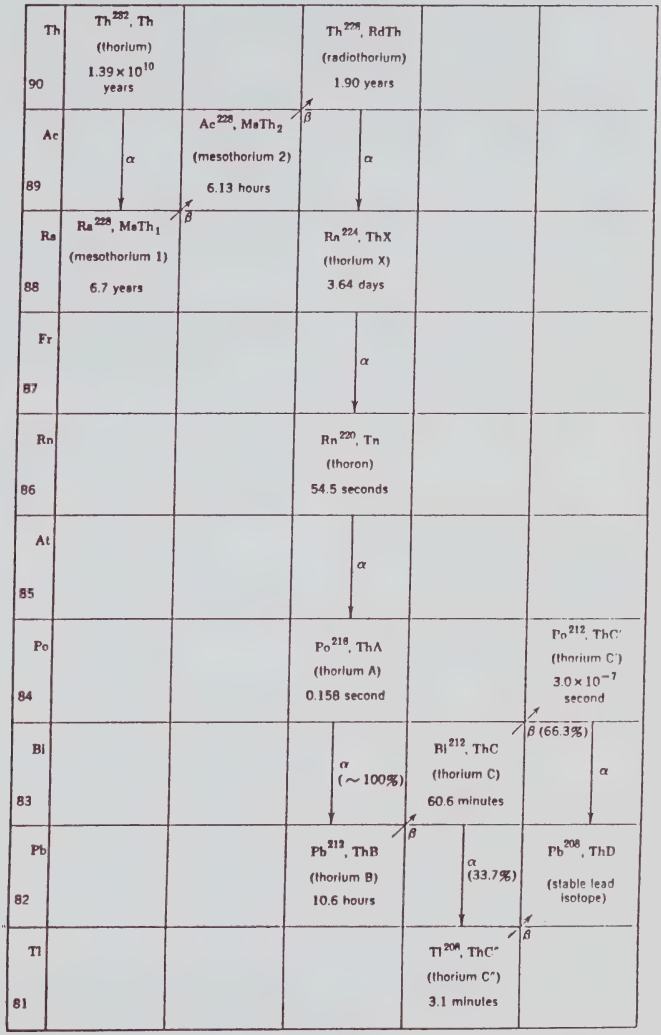
Thorium, like uranium, is found everywhere in the earth's crust, occurring in very small concentrations in all soils and rocks. In certain localized areas, however, above normal concentrations are found, such as in uranium mines in Northern Ontario, where thorium minerals are associated with uranium minerals. In Elliot Lake mines, for example, the ore that is currently being mined has a weight ratio of thorium (Th-232) to uranium (U-238) of one.[1] It is also possible that thorium minerals may be associated with non-uranium ores in Ontario mines or that thorium may occur in above normal concentrations in the rocks surrounding non-radioactive deposits.

The main constituent of elemental thorium found in nature is the radioisotope Thorium-232, which has a half-life of 1.4×10^{10} years. Other thorium isotopes have been identified, but they are all radioactive decay products with much shorter half-lives. Thorium-232 is the parent of a decay series of radioactive species that includes Radon-220 (Rn-220). The members of the decay series are shown in Figure 1. Radon-220, more commonly referred to as thoron, is a dense, inert, radioactive gas with a half-life of about 56 seconds, which decays to stable Lead-208 through a series of radioactive species known collectively as thoron daughters.

Some of the thoron daughters decay by the emission of alpha particles, and, if present in an underground mine atmosphere, can contribute to lung cancer. This is the same health hazard that has been related to excessive exposure to radon daughters.[2]

If there is a mixture of radon daughters and thoron daughters in an underground mine atmosphere, and thoron daughters are not accounted for, i.e. all alpha radiation is ascribed to radon daughters, then the measure of the hazard due to radon daughters is overestimated. A further complication arises because the effect of inhalation of thoron daughters is considered to be less hazardous than that due to inhalation of radon daughters. The Advisory Committee on Radiological Protection, in a report[3] to the Atomic Energy Control Board in 1982,

Figure 1 **The Thorium Radioactive Decay Series.**



stated that the risk of cancer induction by 1 WLM* of thoron daughters is about one-third that for 1 WLM of radon daughters.

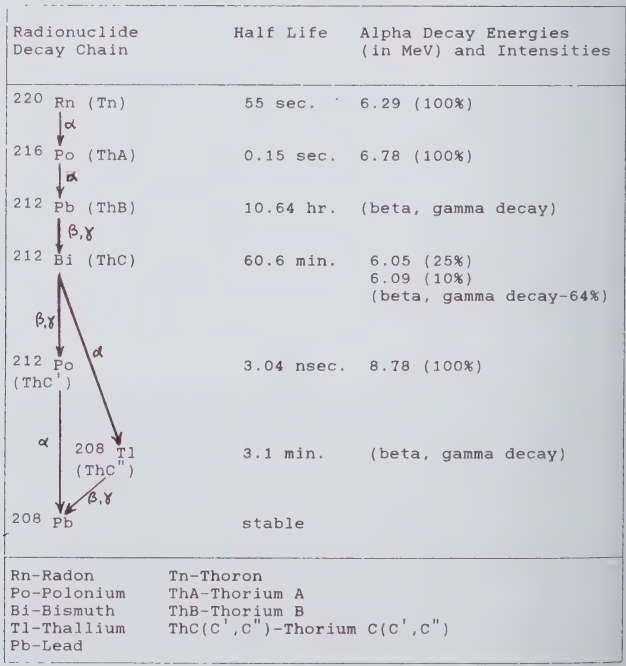
*Working Level Month (WLM): An exposure of one Working Level for a period of 170 hours.
Working Level (WL): Any combination of radon or thoron daughters in one cubic metre of air that will yield a potential alpha particle energy of 2.08 x 10^{-5} joules in decaying to Pb-210 or Pb-208 respectively.

Since the regulatory annual limit for uranium miners is 4 WLM for inhalation of radon daughters[4] this implies an annual limit of about 12 WLM for inhalation of thoron daughters.

Decay Relationships of Thoron Daughters

The thoron daughters decay scheme is shown in Figure 2. The alpha particle emitting radionuclides are thoron (Rn-220), Polonium-216 (Po-216), Bismuth-212 (Bi-212) and Polonium-212 (Po-212). The first two nuclides do not contribute to the health hazard; thoron (Rn-220), because it is gaseous, does not build up in the lung and very few atoms of Po-216 can accumulate because of its short half-life (0.16 sec.). Bi-212 exhibits two decay modes. Two-thirds of the decays involve beta particle emission to form Po-212, which then decays almost instantly (half-life, 0.3×10^{-6} sec.) by emitting an 8.78 MeV alpha particle to form stable Pb-208. The remaining one-third of the decays involve emission of a 6.07 MeV alpha particle to form Tl-208. Thus, for all practical purposes, Bi-212 can be considered to decay with a 60.5 min. half-life by emitting two alpha

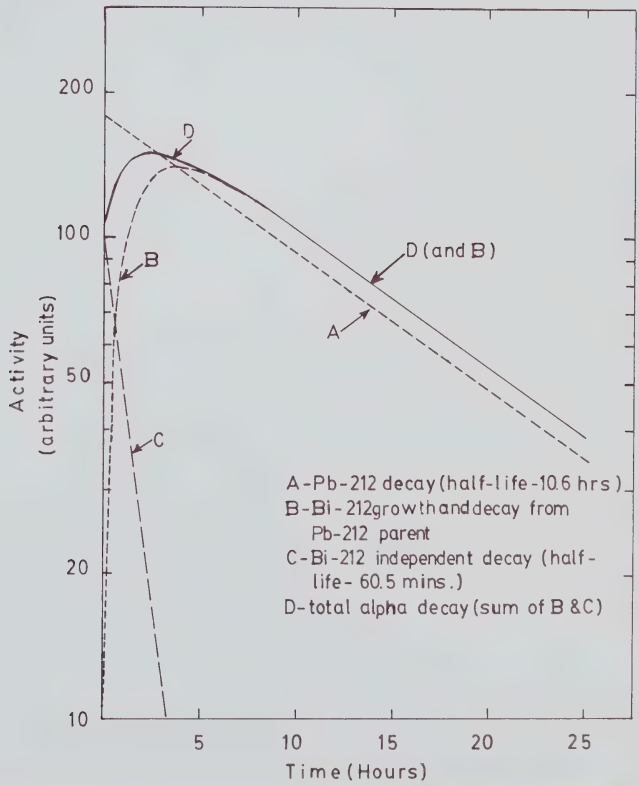
Figure 2 **Main Radioactive Decay Properties of Thoron(^{220}Rn) and Thoron Daughters**



particles. A second process that contributes to the alpha particle emission is the beta particle decay of Pb-212 to form Bi-212. Because the half-life of Pb-212 (10.6 hrs.) is so much longer than that of Bi-212 (60.5 min.), a system of transient equilibrium is established after a period of about four hours in which the Bi-212 activity is observed to decay with the parent (Pb-212) half-life, and the ratio of their disintegration rates becomes constant. An illustration of these decay relationships is shown in Figure 3. That portion of the alpha particle decay due to the growth and decay from Pb-212 is by far the largest contributor (>90%) to the total alpha particle emission of thoron daughters.

Figure 3

Relationship of Decay Modes of Pb-212, Bi-212 and Bi-212 in Equilibrium with Pb-212 Parent.



Theory of Measurement and Method Used

The determination of the concentration of thoron daughters in an underground mine atmosphere when radon daughters are also present is facilitated by the fact that the

alpha activity of radon daughters (as a group) is observed to decay with a half-life of about 30 minutes. At about five hours after a particulate sample is collected, the residual alpha activity of the radon daughters will be negligible. As shown in Figure 3, at about this same time, the alpha activity of the thoron daughters will be decaying with a half-life of 10.6 hrs. A series of about four counting rate measurements taken at two-hour intervals will serve to establish the 10.6-hr. half-life. The concentration of thoron daughters can then be calculated from any one of the measurements by means of the following formula:

$$\text{Thoron daughter Concentration (WL)} = \frac{C_{gt} - C_b}{E \times V \times F_{dt}}$$

Where C_{gt} is the gross counting rate after time t,
C_b is the background counting rate of the alpha counter,
E is the efficiency of the counter for alpha particle detection,
V is the total volume of air sampled,
F_{dt} is the correction factor for time t for converting to WL units, and
t is the elapsed time from end of the sampling period to the mid-point of the counting period.

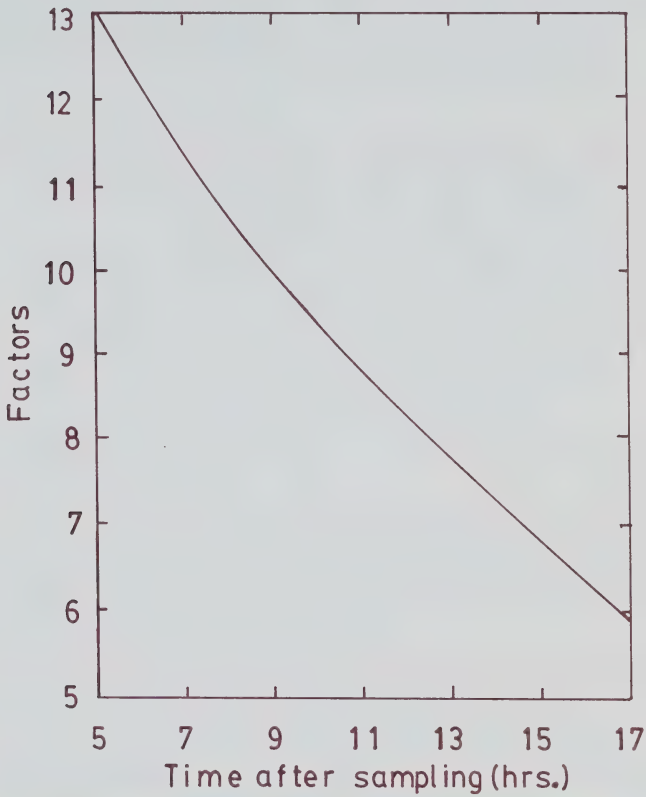
The correction factors[5] for converting to WL units for elapsed times of five to 17 hours after sampling are shown in Figure 4.

A particulate sample is collected by drawing a known volume of air through a membrane filter with an air sampling pump. An open-faced filter holder fitted with a 25-millimetre diameter, 0.8 micron Millipore filter is used. The air sampling pump is battery operated and the air flow is calibrated prior to taking the samples. A total volume of between 35 to 40 litres of air, depending on the pump flow rate, is collected over a period of exactly five minutes. The time at the start of sampling is recorded. From about five hours after sampling, a series of four measurements at two-hour intervals is made of the alpha activity on the filter.

The samples are counted, using a Trimet Model TM 372A alpha scintillation counter. The start time and duration of each measurement are recorded. The concentration of thoron daughters is then calculated by applying the formula above.

Figure 4

Correction Factors for Converting to WL Units for 5 to 17 Hours After Sampling (From MESA Report 1015, 1975).



Survey Details and Results

The concentration of thoron daughters in underground mine air was measured in three non-uranium mines in Northern Ontario. These mines were considered by the Mining Health and Safety Branch as being locations with the highest potential for finding significant quantities of thoron daughters. Accordingly, visits were made to these mines in April, May and September 1986. In addition to measuring the thoron daughter concentrations, measurements of radon (Rn-222) gas and radon daughter concentrations were made in areas representative of fresh airways, active work areas and return airways in all three mines.

A total of 61 air samples for thoron daughter measurements were collected in the three mines visited. As can be seen in Table 1, the measured concentrations ranged

Table 1 **Concentrations (in WL) of Thoron Daughters Measured in Three Non-Uranium Mines in Northern Ontario.**

Mine	Site	Fresh air conc. (WL)	Site	Work place air conc. (WL)	Site	Return or Exhaust air conc. (WL)
A	1	0.001	2	0.005	4	0.003
	3	0.005	5	0.001	7	0.001
	9	0.002	6	0.002	10	0.005
	13	0.004	8	0.003		
			11	0.005		
			12	0.004		
B	9	0.002	3	0.018	1	0.005
			4	0.019	2	0.001
			5	0.021	6	0.006
			7	0.004	8	0.007
			11	<0.001	10	0.006
			12	0.001	20	0.002
			13	0.003		
			14	0.003		
			15	0.003		
			16	0.003		
			17	0.003		
			18	0.002		
			19	0.002		
C	1	<0.001	2	0.007	7	0.004
	3	<0.001	4	0.004	9	0.005
	5	<0.001	6	0.002	13	0.006
	10	<0.001	8	0.003	16	0.010
	17	<0.001	11	0.002	19	0.005
	21	<0.001	12	0.005	27	0.004
	26	<0.001	14	0.002	28	0.006
			15	0.004		
			18	0.006		
			20	0.003		
			22	0.005		
			23	0.004		
			24	0.003		
			25	0.001		

from <0.001 to 0.02 WL. Also, there is a trend to higher concentrations in 'work area' and exhaust (or return) air than in fresh air. These concentrations are, however, extremely low and are not considered hazardous. For example, a miner working continuously for one year (2,000 hrs.) in an area at the highest concentration (0.02 WL) would be exposed to a total of 0.24 WLM. This is a very small fraction of the suggested annual exposure limit (12 WLM) for a miner.

Discussion

Also, these levels of thoron daughter concentrations do not affect the radon daughter measurements. Radon daughter concentrations were measured simultaneously with thoron daughter concentrations in three locations where the highest thoron levels were found. Corrections to the radon daughter concentrations, calculated to account for the presence of thoron daughters, amounted to one per cent. This correction is insignificant when compared to the error inherent in the method for measuring radon daughter concentrations, which is of the order of 12 to 15 per cent.

Conclusion

All the levels of thoron daughter concentrations observed are very low. They do not constitute a health hazard and, in addition, do not significantly affect the measurements of radon daughter concentrations.

Résumé

Le minerai extrait de certaines mines autres que des mines d'uranium présente parfois des traces d'uranium et de thorium. Si tout le rayonnement alpha mesuré dans l'atmosphère est attribué aux descendants du radon sans tenir compte des descendants du thoron, on risque de surestimer l'exposition des mineurs aux descendants du radon et d'enfreindre la loi en vigueur.

Cet article étudie la présence de thoron et de ses descendants dans trois mines n'extrayant pas d'uranium. Il présente la théorie et la méthode sur lesquelles s'appuient les mesures. Les résultats obtenus montrent que le thoron n'est pas un problème significatif dans les mines étudiées.

Acknowledgements

The authors would like to thank the Mining Health And Safety Branch of the Ontario Ministry of Labour and the two Ontario mining companies for their co-operation and assistance during the course of this investigation.

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Video Display Terminals – Do They Emit Dangerous Levels of Radiation?

Summary

The Associate Committee on Scientific Criteria for Environmental Quality was established to develop scientific guidelines for defining the quality of the environment. This paper is an evaluation of available information on the probability of effects of exposure to radiation from video display terminals.

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Introduction

Video display terminals (VDTs), also known as visual display units (VDUs), cathode ray tubes (CRTs) or monitors, are becoming more and more common. Although they have already seen wide use in television receivers, they are now appearing by the thousands as an integral part of business computers, word processors, video games and personal computers. They are used in government offices, throughout business and industry, in schools and in private homes. Numerous questions have been raised about their potential effect on the health of operators.

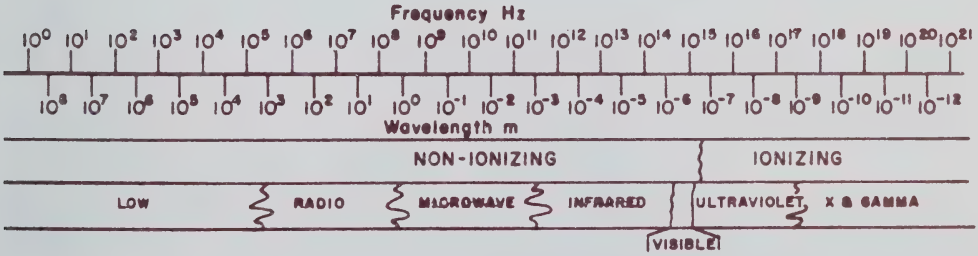
Many agencies and task forces have studied the questions raised by the widespread introduction and use of VDTs in particular and of microelectronic technology in general. They have identified a number of 'problems' related to the physical layout of the equipment and the environment in which it is installed (ergonomic and human factors aspects), and the processes by which the new technology is introduced and how it changes jobs and prospects for advancement or employment (social, political and psychological aspects). Not the least of these 'problems' has been the widespread fear of radiation and associated suggestions that a variety of health problems such as headaches, skin rashes, cataracts and other damage to the visual system, miscarriages and birth defects are caused by radiation emissions from VDTs (scientific, technical and medical aspects). The assessment of radiation effects is within the terms of reference of the Physical Energy Phenomena (PEP) Subcommittee of the National Research Council of Canada's Associate Committee on Scientific Criteria for Environmental Quality. Consequently, and also because of distortions and misinformation presented in the news media and by some special interest groups, the PEP subcommittee has prepared this document to provide the Canadian public, government agencies, unions and business with accurate information about the various radiation-related aspects of VDTs.

Radiation

As soon as they see or hear the word radiation, many people think of atomic bombs, nuclear reactors, radioactive wastes, cancers and birth defects. Radiation is actually a more general term that describes the transfer of energy from one place to another without any obvious connecting link like a pipe or wire in between. Light is a form of radiation. Information displayed on a VDT screen reaches the eye by means of visible electromagnetic radiation (light). The eye focuses this visible radiation on the retina, and the brain interprets the image of the display produced there. An extremely bright VDT display would be difficult to look at directly. An incandescent light, for example, is too bright to look at from a short distance. It also emits infrared radiation, whose effect may be noticed by a warming of the skin.

Since the term radiation refers to the transfer of energy in general, it covers an extremely broad range of effects that includes the whole so-called electromagnetic spectrum, which is commonly broken down into seven sections: X-ray, Ultraviolet (UV), visible, infrared (IR), microwave, radiofrequency (RF) and low frequency (LF). These are shown in Figure 1. Static electric and magnetic fields, although not associated with radiated energy, also may be found in the vicinity of electrical and electronic equipment. Sound, including infrasound and ultrasound, constitutes yet another form of radiation that transmits energy or information by means of mechanical vibrations in the materials through which it travels.

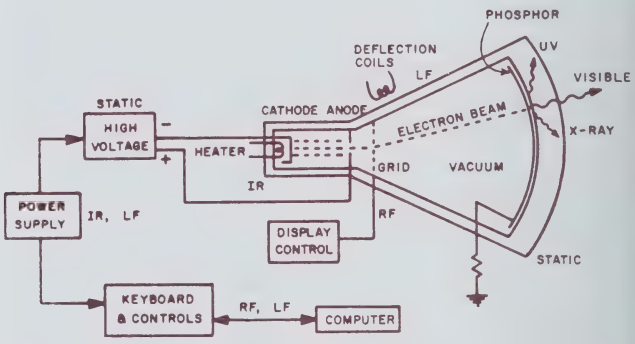
Figure 1 **Electromagnetic Radiation**



How VDTs Work

The key element in any VDT is a display device, usually a TV picture tube, which is a rather large glass vacuum tube with a phosphor coating on the inside surface of its thick and fairly flat front face (Figure 2). An electron beam projected from the back of the tube hits the phosphor and causes it to glow. At the point where the electron beam strikes the phosphor, X-ray, UV, visible and IR radiations are generated. In addition, partly because of the constant flow of electric current (the electron beam) to the front face of the picture tube, a static charge can build up there.

Figure 2



The electron beam is moved around and turned off and on to light up different spots on the phosphor-coated screen, thus generating the display. The beam steering is usually done by magnetic fields produced by coils of wire (deflection coils) mounted near the back of the tube. These coils and the circuit that drives them give rise to emissions in the LF region of the spectrum. Mechanical effects in these components and circuits can also produce acoustic emissions in the ultrasonic region. The beam is turned off and on by a grid electrode controlled by a computer within the VDT. It is often possible to observe emissions in the RF region from these circuits, which also produce emissions in the LF region as a result of keying operations, page and line scrolling and other control operations.

At the back end of the tube the electron beam is projected from an electron gun. The electrons are released from a heated cathode. They are then accelerated toward the anode by a high voltage (around 15,000 volts). They

pass through a hole in the anode and proceed through the control fields to the screen. The various components in the circuits of the power supply, high voltage supply, keyboard and control circuits all heat up to some degree and consequently emit IR radiation. Finally, there are detectable fields in the LF region that result from the display refresh circuits and the line frequency (60 Hz) power connection.

The rest of this document deals with each type of electromagnetic radiation in turn. The limits referred to below are based on regulations or, where regulatory action has not been taken, on standards and guidelines proposed by widely recognized and authoritative agencies such as the Bureau of Radiation and Medical Devices (formerly the Radiation Protection Bureau) of Health and Welfare Canada, the Centre for Devices and Radiological Health) (formerly the Bureau of Radiological Health), the National Institutes of Occupational Safety and Health (NIOSH), the U.S. Occupational Safety and Health Administration (OSHA), the British Health Canadian Federal-Provincial Subcommittee on Radiation Surveillance, the National Research Council of Canada's Associate Committee on Scientific Criteria for Environmental Quality (through its former Subcommittee on Physical Energy Phenomena), the Physical Agents Threshold Limit Values (TLV) Committee of the American Conference of Governmental Industrial Hygienists (ACGIH) and the Standards Committees of the American National Standards Institute (ANSI). All these agencies and committees are in broad, general agreement on the limits they propose, although there are some differences in details. They arrive at their recommendations after reviewing the scientific literature in each area and by assessing its significance to workers and the public at large.

Scientists who specialize in the evaluation of the effects of exposure to radiation are unanimous in the view that the levels of radiation generated by VDTs do not constitute a hazard to the health of an operator or to a developing fetus that may be present.

X Radiation

X radiation is a form of electromagnetic radiation. It is at the extreme high frequency end of the electromagnetic spectrum. When it interacts with matter it can separate electrons from atoms and leave along its path a trail of charged atoms, which are called ions. Thus X radiation is also called ionizing radiation. Other forms of electromagnetic radiation that do not leave a trail of ions when they pass through matter are called non-ionizing radiations.

The magnitude of an exposure to ionizing radiation may be expressed in terms of the ionization it produces in air. The quantity is called *exposure* and its modern unit is coulombs per kilogram ($C.kg^{-1}$). The former unit was the roentgen (R) and 1 $C.kg^{-1}$ = 3,876 R. The biological dose received by a person from an exposure to radiation is known as the *dose equivalent*. The modern unit of this quantity is the sievert (Sv) and the former unit was the rem. 1 Sv = 100 rem. Very approximately, an exposure of 1 R from X- or gamma radiation delivers a dose equivalent of 10 mSv, or 1 rem.

People are continually exposed to many sources of ionizing radiation. Some examples of these so-called background sources are the radioactive materials in the earth (and in building materials), naturally-occurring radon gas and its radioactive decay products, cosmic radiation from the sky, radioactivity in foods and residual fallout from atmospheric weapons tests. People are even exposed to ionizing radiation from within their own bodies. The main source of this exposure is the natural radioactivity of the 140 g of potassium in their lean tissue mass. To a smaller extent, people are also exposed to radiation from the radioactivity in the bodies of others in their close proximity. Less frequently, additional exposure results from X-ray examinations and from enhanced levels of cosmic radiation received during air travel at high altitudes. An average Canadian would receive a dose equivalent of about 2 mSv (200 mrem) each year from all of these sources. Residual fallout causes about 0.03 mSv (3 mrem), a single chest X-ray would add about 0.4 mSv (40 mrem), and an upper gastrointestinal tract examination would add 6 mSv (600 mrem) or more to an individual's dose.

By way of comparison, the X-ray emissions from a VDT are so low that they are all but impossible to detect. It has been calculated that a person working eight hours a day for 250 days of the year *might* receive as much as 0.05 mSv (5 mrem) each year to the part of the body closest to the VDT – a rather insignificant addition to the total annual exposure. Measurements done by the Radiation Protection Bureau of Health and Welfare Canada show that the actual yearly doses are less than one thousandth of this estimate. It becomes clear that this dose is insignificant when one considers what has been discovered about the effects of exposure to ionizing radiation.

A dose of about 5 Sv (500,000 mrem), delivered to the whole body in a short time (for instance, in an atomic bomb explosion), will result, within a couple of weeks, in

the death of about half of the people so exposed. The same dose spread out evenly over a whole year would not likely produce any noticeable early effects. However, it is known that in the next few years there would be an obvious increase in the incidence of leukemia, cancer and birth defects among the exposed people.

By contrast, if the dose of 5 Sv (500,000 mrem) is reduced by a factor of 2,500 to 2 mSv (200 mrem), and spread out over a whole year, it becomes equivalent to background radiation. The effect of thus doubling the natural background exposure cannot be distinguished from the other detriments to human well-being that are in our environment. The contribution from VDTs, if any at all, would be *at least* a factor of 40 or 50 less.

Whenever electrons pass through a vacuum in the presence of a high voltage and strike a target material, X radiation is produced. The penetrating ability of the X radiation depends on how high the voltage actually is – the lower the voltage, the lower the penetrating ability. Medical diagnostic X-ray equipment is usually operated between about 70,000 and 100,000 volts. Colour television sets and VDTs with full colour displays may operate as high as 25,000 or 30,000 volts, but single colour VDTs (white, green, orange, etc.) virtually all operate below 20,000 volts. Even at 30,000 volts , the thick glass face of the CRT is a very good shield against the X radiation produced inside the tube.

Measurements, made with portable equipment that has relatively low sensitivity, on thousands of VDTs in a variety of different office settings, have shown that emission levels do not exceed one-tenth of the limit permitted by federal regulation. Laboratory measurements with much more sensitive equipment on fewer units failed to detect emissions in excess of natural background levels. Indeed, there are data available indicating that emissions are less than one-thousandth of background.

Thus, even though X radiation is generated at the inside surface of the thick glass of the display tube, it is virtually all absorbed by the glass face of the tube because the radiation is not very penetrating and the glass is quite thick. Furthermore, the very low level of X radiation that might be emitted from the surface of any VDT is further attenuated by superficial body tissues before it can reach a fetus or the ovaries. In contrast, X radiation for medical and dental diagnosis is generated by machines that use much higher voltages than those present in a VDT since the radiation must be more penetrating to pass through the body and produce an 'X-ray picture' for the medical or dental examination.

Ultraviolet (UV) Radiation

Ultraviolet radiation lies between X radiation and visible radiation (light) in the electromagnetic spectrum. It forms a bridge between the ionizing and non-ionizing regions of the spectrum. It has wavelengths that are too short to be detected by our eyes and therefore it is not visible. It is present in sunlight and it can cause sunburns (erythema), eye irritation (photokeratitis and conjunctivitis) and photosensitization. It has been associated with skin cancer and premature aging of the skin.

Some radiation in the UV region is emitted by some phosphors (the light-emitting material coated on the inside surface of the face of the display tube). In addition, the electrons responsible for producing X radiation also produce some UV directly by similar processes.

However, although some UV may be present within the CRT, it is not emitted in any significant amounts because the thick glass face of the display tube is an excellent absorber of UV, especially of the shorter and more damaging wavelengths of the UV spectrum. Furthermore, laboratory measurements have shown that any UV emissions are several hundred times below the limit recommended for exposures of up to eight hours per day.

Visible Radiation

Visible radiation is light. It is non-ionizing electromagnetic radiation in the very narrow range of frequencies or wavelengths that can be detected by our eyes. We are often exposed to the sun, a source of very intense visible radiation. The sun also emits large amounts of UV and IR radiation, measurable amounts of microwave and RF radiation and even detectable (by satellites, in space) amounts of X radiation.

Measurements have shown that the brightness level of the display of a VDT, which is usually adjustable for operator comfort, is, even at maximum, well below levels considered acceptable for extended viewing, and thus the display would not be considered hazardously bright. The light level from a VDT is generally much less than from a domestic TV except when the VDT uses a reverse video display, and then they are comparable.

The colour of the display – green, orange, etc. – is determined by the phosphor used in the VDT. A mixture is used for 'white' displays and a combination (red, green and blue) is used for colour displays. After-images and colour perception shifts can occur as a result of looking at high contrast or single colour visual fields. If such visual fields are also very bright, the feeling that the scene is burned right into the eyes is created. However, VDTs do not

produce sufficient contrast or brightness for such effects to be strong enough to be damaging to the eyes or otherwise hazardous to the operator.

Infrared (IR) Radiation

Infrared (IR) radiation is commonly referred to as radiant heat. It is what you feel when standing near an open fire or any hot object. IR radiation is adjacent to visible light in the electromagnetic spectrum, at the red end of the visible region. It has wavelengths that are too long to be detected by our eyes and, thus, is not visible. It is another form of non-ionizing electromagnetic radiation.

At high intensities IR radiation can cause skin burns. In industries where workers are exposed to very hot materials (molten metal or glass) it has been associated with the production of cataracts. However, the pain-sensing nerve endings in human skin provide a very effective warning indicator for IR exposures. Excessive exposure to strong sources of IR radiation, such as an open fire or a hot stove element, causes pain in exposed skin, which forces one to move away.

As is common with any electrical or electronic equipment, VDTs heat up to some extent whenever they are turned on. Thus, they become sources of IR radiation. Furthermore, the emission characteristics of some phosphors are such that they emit some radiation in the IR region.

Laboratory measurements on VDTs have shown that IR emissions from them are about 500 times less than the recommended occupational exposure limit and about 5,000 times lower than is required to feel 'warmth'. The warmth of the air blowing out of the VDT's cooling system should not be confused with IR radiation. Although that air has been partly heated by IR radiation within the VDT, most of its warmth results from contact with hot components in the VDT. The warmth you feel in that air stream is from contact with warm air rather than from exposure to IR or any other form of radiation.

Microwave Radiation

Microwave radiation is yet another type of non-ionizing electromagnetic radiation, but it has wavelengths even longer than those of IR radiation – roughly between one and 1,000 millimetres. Microwave radiation is used for radar and communications and, for cooking purposes, in microwave ovens.

Microwaves are generated by very high frequency (billions of cycles per second) variations of electric current or voltage. VDTs and their associated computers do not normally operate on or generate such very high frequency variations. However, as computer technology

advances, higher frequency signals in the microwave region of the spectrum will become more common, and microwave emissions will likely be detected near such advanced equipment.

The risk of cataracts is usually considered to be the most significant result of exposure to microwaves at intensities that are high enough to cause heating of the lens of the eye. In experiments with animals under exposure conditions where the heating of tissues has been shown to occur, effects such as resorption of fetuses, birth defects and blood and nervous system disorders have also been reported. However, such effects have not been found under exposure conditions corresponding to exposures at or below recommended limits.

Measurements at microwave frequencies near VDTs detect only background levels that are more than a million times less than the recommended limits in Canada.

Radiofrequency (RF) Radiation

Radio Frequency (RF) radiation is another type of non-ionizing electromagnetic radiation, which has wavelengths in the range of metres to kilometres. It is used to broadcast AM and FM radio and TV signals and also for CB, taxi and police, fire and other emergency communications.

Experiments with animals at very high exposure levels have indicated that RF radiation may cause a variety of effects associated with heating of the exposed tissue. However, where exposures do not exceed the recommended limits, there are no indications that such effects can occur in humans.

RF radiation is generated by high frequency (thousands or millions of cycles per second) variations of electric current or voltage. VDTs and their associated computers, like most other electrical and electronic equipment, routinely operate on and generate RF signals.

Inasmuch as virtually every piece of electrical or electronic equipment emits detectable amounts of RF radiation, VDTs are similar to radios, TVs, calculators, electric hand tools, shavers, hair dryers or automobile ignition systems. Laboratory measurements on VDTs show that the emission levels are more than a million times less than recommended limits. It has also been shown that, at any given location in a typical modern urban area, the total exposure to RF radiation from radio, TV and communications signals is greater than the exposure an operator might receive from operating a VDT.

Low Frequency (LF) Radiation

Low Frequency (LF) emissions are electric and magnetic field variations that occur at a rate of a few through a few thousand cycles per second. The frequency used by utility companies to feed electrical energy from generating stations to homes and industry (60 Hz) is in this portion of the spectrum. LF emissions constitute yet another form of non-ionizing radiation that is emitted from VDTs.

LF signals are observed near the back or sides of VDTs, but they can also be observed near any other electrical or electronic equipment. Many domestic appliances such as electric blankets, stoves, toasters, refrigerators, etc. produce much stronger LF fields than those measured near VDTs.

An LF signal that can easily be detected near the back or sides of VDTs and TV receivers occurs at about 15,000 Hz and its harmonics. This emission comes from the high voltage circuit and results from the signal used to scan the electron beam back and forth across the face of the display tube. These signals have been found to be much stronger near sets with non-metallic cabinets. Recently, to forestall growing speculation, controversy and criticism about these emissions, most manufacturers have been taking steps to reduce the levels emitted by their equipment. But it remains a fact that the levels at the usual operator's position have been, and continue to be, far less than the recommended limits for this frequency region.

It has also been suggested that LF emissions, especially when modulated or pulsed at frequencies observed to occur in electroencephalograms (brain waves), might somehow affect people exposed to them. All such reports available to date are quite speculative, and indications from the scientific literature are that LF fields hundreds of times stronger than those observed near VDTs – pulsed, modulated or not – do not produce harmful effects.

Static Fields

Static electric fields occur when surfaces or objects collect an electric charge that is not carried away to ground. Their effect is usually experienced as a spark jumping from the fingers to a doorknob. This is especially common indoors under dry winter conditions.

Static fields can often be detected at the front face of a VDT or TV set. Sometimes the keyboard and enclosure (especially if plastic) will also carry a static charge.

The tiny sparks that occur in the presence of static fields can be annoying and, if they occur repeatedly, stressful. They can also cause the machine to malfunction and, possibly, cause the loss of a document or the failure of a component. For these reasons, many suppliers advocate the use of static control measures (humidifiers, static eliminators, conductive carpeting) to prevent such sparks. It has also been reported that operators become charged as a result of contact with VDTs. Consequently, it was suggested that dust particles and pollen can be attracted to them and cause allergic reactions. The possibility that this might occur can also be reduced by the use of static control measures.

However, apart from the annoyance caused by the tiny sparks, neither the sparks nor the fields have been shown to produce harmful effects in humans at the levels observed near VDTs. Even much higher fields have not been shown to be harmful. Papers reporting allergic skin reactions (rashes) secondary to exposure to static fields from VDTs noted that low humidity and carpets without antistatic qualities both had to be present for the observed effects to occur. They did not report on the incidence of rashes under similar conditions among workers who did not use VDTs. Thus, whether such effects are substantiated or not still remains to be determined.

Static magnetic fields are not to be expected in or around VDTs as such. The earth's magnetic field and residual fields from metallic furniture or building structures will be the main sources of static magnetic fields to which operators might be exposed. There are no indications that such fields produce harmful effects. Indeed, magnetic fields that are tens of thousands of times larger are used in magnetic resonance imaging procedures, and are considered harmless.

Ultrasound

As was mentioned in the Introduction, mechanical vibrations associated with the electron beam scanning control circuits can make some components in a VDT act like a very high frequency loudspeaker. In fact, the frequencies produced are so high that they are beyond the range of hearing of all but quite young people (up to the early 20s), who may hear or complain about a high pitched whistle or squeal from some machines. Such high frequency sound is sometimes called ultrasound. However, the term is more properly used to describe the very high frequency acoustic energy used in physiotherapy, in ultrasonic cleaners or in medical diagnostic procedures (for example, in examining the fetus during pregnancy).

Although the high frequency, 'ultrasonic', emissions may be annoying in the same way that the hiss from air conditioning systems or the hum from some lighting fixtures might be annoying, measurements indicate that the intensities are too low to produce any harm. For those people who can perceive the 'ultrasound', the annoyance can be minimized by conventional sound deadening techniques.

Old or Defective VDTs

It is often suggested that something could break down or fail in a VDT and cause radiation emissions to rise suddenly and without the operator's knowledge. In order to obtain information about this question, the U.S. Bureau of Radiological Health (BRH) undertook a study of 125 VDTs available on the open market. X-ray emissions were measured under extreme test conditions for which (a) line voltage is raised to 130 V from its normal value of 110 V, (b) both user and service controls are adjusted so as to maximize emissions, (c) the most important component or circuit failure is deliberately introduced, and (d) the screen still must generate a readable display. They reported that under these extreme conditions eight machines emitted between 0.5 and 2 $mR.h^{-1}$ (i.e. in excess of the regulatory limit of 0.5 $mR.h^{-1}$), two other machines emitted detectable levels under 0.5 $mR.h^{-1}$ and the other 115 emitted 0.0 $mR.h^{-1}$. The conclusion that can be drawn from this is that only in situations as bad as the extreme test conditions might 10 per cent of VDTs produce detectable (though not necessarily hazardous) X-ray emissions.

It is extremely unlikely that a chain of coincidences as bad as the test conditions could ever occur during actual use of a VDT.

It is also extremely unlikely that emissions could rise to dangerous levels in the event of an ordinary component failure. The power supply and other circuits are designed to keep currents and voltages within certain limits so that, even in the event of a component failure, X-ray emissions will not exceed the regulatory limit. As with a TV set at home, when a component fails, the most likely result is a degradation in picture quality or in some other performance aspect of the system, which thus terminates the exposure situation.

It is also often suggested that radiation emissions can increase as a VDT gets older. It is clear that, as VDTs get older, the effects of humidity, dust, temperature variations or vibration can result in component failures and unsatisfactory performance or display quality. In addi-

tion to component failures, the brightness of the phosphor usually decreases as the tube ages. However, neither this nor any other effects of aging would result in significantly increased emissions.

A Final Word on Radiation

VDTs, like most other office machines or domestic appliances, do emit detectable amounts of various kinds of radiation. Recommended limits for all these radiations have been agreed upon by government and licensing agencies. Testing has covered a wide variety of makes and models and the whole gamut of applications from word processors to data entry and computer terminals in government and business to editorial, typesetting and classified ad departments in newspapers. Furthermore, testing has covered machines ranging from those that were a number of years old and wheeled around from one work station to another, to new machines that had been unpacked the very day that measurements were carried out. The tests confirm that operator exposures to the various radiations are all well below the recommended limits and there is no reason to believe that VDTs are a hazard to the health of any operator or to a developing fetus. Thus, because there has never been a single substantiated report of a significant level of emission of any type of radiation in thousands of VDTs tested in offices throughout the world, precautions such as the routine monitoring of VDTs for radiation emissions, the transfer of pregnant operators to other jobs, the use of lead aprons or the installation of any extra shields or screens are quite unnecessary.

A Brief Note on Statistical 'Clusters'

Many operators of VDTs are alarmed by frequent reports of so-called 'clusters' of miscarriages, birth defects and other adverse pregnancy outcomes. It is not surprising that a pregnant operator of a VDT would become concerned for the safety of the child she is carrying after hearing about a situation such as was reported at the *Toronto Star* in 1980. In seven pregnancies among about 150 VDT operators in a one-year period, four resulted in children with birth defects.

However, two simple facts should serve to reassure anyone who is alarmed by such reports. First, a careful evaluation of radiation emissions and other physical and chemical factors in the environment did not reveal anything abnormal. Second, in a sample of pregnancies as small as seven, almost anything, even seven abnormal outcomes, can be expected to occur once in a while. In other words, even though such an occurrence will be

very rare, it can be expected actually to happen when consideration is given to the large number of VDT operators in Canada. Furthermore, if the occurrence at the *Star* had been 'real' rather than a statistical fluctuation or 'cluster', there would have been an average of about four cases of birth defects in the same group of VDT operators (and every other group of 150 operators) in each subsequent year. This, of course, has not occurred. Thus, although the rarity of such an occurrence makes it worthy of note and results in its receiving a great deal of publicity, as well as intense study of the working environment by responsible experts, it is not an indication of any hazard to a pregnant VDT operator or her fetus.

Laboratory Results for a Typical VDT
(Wolbarsht et. al., 1979)

X-Ray (>10 keV)	$0.003\ mR.h^{-1}$ (0.5) *
Far UV (200 nm – 320 nm)	$1.25 \times 10^{-4}\ \mu W.cm^{-2}$ (0.1) **
Near UV (320 nm – 400 nm)	$1.8 \times 10^{-2}\ \mu W.cm^{-2}$ (1,000) **
IR (700 nm – 4.1 μm)	$2 \times 10^{-3}\ mW.cm^{-2}$ (10) **
Microwave, E-field (10 MHz – 10 GHz)	$7.26 \times 10^{-9}\ mW.cm^{-2}$ (1,5) ***
RF & LF, E-field (1 kHz – 10 MHz)	$1.3 \times 10^{-5}\ mW.cm^{-2}$ (10,000, 100, 1) **
RF & LF, H-field (1 kHz – 10 MHz)	$3.03 \times 10^{-5}\ mW.cm^{-2}$ (10,000, 100, 1) **

* Federal Regulation.
** Provincial Recommendation (Ontario).
*** Federal Safety Code.
( ) In right-hand column indicates guideline value. Two or more values indicate change of guideline within range given at left.

Typical Field Survey Results – 350 Machines
(Ontario Ministry of Labour)

X-Ray (>6 keV)	< 0.05 mR.h^{-1} (0.5) *
Microwave, E-field (300 MHz – 20 GHz)	<0.05 mW.cm^{-2} (1,5) ***
RF & Microwave, E-field (10 MHz – 2.45 GHz)	<0.5 mW.cm^{-2} (1,5) ***
RF, H-field (10 MHz – 300 MHz)	<0.05 mW.cm^{-2} (1) ***
LF & RF, E-field (10 kHz – 200 MHz)	<1 V.m^{-1} (600, 60) **
Static, E-field (<1 Hz)	<1 kV.m^{-1} (10) **

* Federal Regulation.
** Provincial Recommendation (Ontario).
*** Federal Safety Code.
( ) In right-hand column indicates guideline value. Two values indicate change of guideline within range given at left.
< In right hand column indicates emission too small to be detected. Number indicates sensitivity limit of instrumentation used.

Mandate of the Associate Committee on Scientific Criteria for Environmental Quality

The Associate Committee on Scientific Criteria for Environmental Quality was established by the National Research Council of Canada in response to a mandate provided by the federal government to develop scientific guidelines for defining the quality of the environment. The concern of the NRCC Associate Committee is strictly with scientific criteria. Pollution standards and objectives are the responsibility of the regulatory authorities and are set for the purpose of pollution control. These may be based on scientific criteria as a starting point, but they also take into account the optimal socio-economic impact of proposed measures as well as the state of existing technology.

The associate committee's program includes the evaluation of available information on the probability of effects of contaminants on receptors together with the related fundamental principles and scientific knowledge.

In this work particular attention is directed to receptors and contaminants (and their interactions) important to Canada. This Canadian approach is necessary because evaluations made in other countries or regions will not always be applicable to the particular circumstances prevailing in Canada.

Members of the associate committee, its subcommittees and expert panels, serve voluntarily and are selected for their individual competence and relevant experience with due consideration for a balance among all sectors in Canada. Responsibility for the quality of study documents rests with the associate committee. Each report is carefully reviewed according to a multistage procedure established and monitored by the National Research Council of Canada in order to preserve objectivity in presentation of scientific knowledge. Publication and distribution of the reports are undertaken only after completion of this review process.

Comments on associate committee documents are welcome and will be carefully reviewed by the expert panels. It is foreseen that these scientific criteria may be revised from time to time as new knowledge becomes available.

Résumé

Le comité associé sur les critères scientifiques concernant l'état de l'environnement a pour mandat d'établir des directives scientifiques pour la définition de la qulalité de l'environnement. Cet article évalue les données disponibles sur les effets potentiels de l'exposition aux rayons émis par les écrans cathodiques.

Acknowledgements

This document was prepared as part of the program of the former Subcommittee on Physical Energy Phenomena, and the author would like to thank the members of that subcommittee for their encouragement and suggestions.

Note to Readers

Readers of this document on VDT's will note that it does not follow the usual format of the criteria documents issued by the Associate Committee on Scientific Criteria for Environmental Quality in that it does not contain references to the scientific literature in the body of the document. Such references have not been included because the associate committee intends that the document on VDTs simply convey to readers an assessment by recognized, experienced, professional scientists of all the criteria issues connected with the use of VDTs without encumbering the document with all the technical references essential to a criteria document.

The bibliography at the end of the document directs any interested reader to criteria documents and a few other key articles where all the appropriate technical references are available. The publications and articles listed should give anyone interested a clear and suitably referenced picture of the rationale applied in reaching the stated conclusions. Furthermore, much of the content of the document is at such a very basic scientific and technical level that citation of references is felt to be quite inappropriate.

Editor's Note

The editor thanks the chairman of the associate committee for permission to publish this article.

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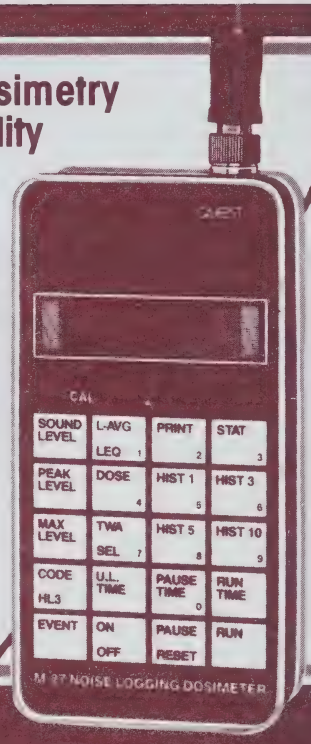

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Regulation respecting Mercury – made under the Occupational Health and Safety Act Ontario Regulation 141/82 as amended by O.Reg. 23/87

Regulation respecting Vinyl Chloride – made under the Occupational Health and Safety Act Ontario Regulation 516/82 as amended by O.Reg. 23/87

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Regulation to Amend Regulation 691 of Revised Regulations of Ontario, 1980 Ontario Regulation 156/84

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Regulation respecting Teachers – made under the Occupational Health and Safety Act Ontario Regulation 191/84

Regulation respecting University Academics and Teaching Assistants – made under the Occupational Health and Safety Act Ontario Regulation 307/84

Regulation respecting Benzene – made under the Occupational Health and Safety Act Ontario Regulation 732/84 as amended by O.Reg. 23/87

Regulation respecting Acrylonitrile – made under the Occupational Health and Safety Act Ontario Regulation 733/84 as amended by O.Reg. 23/87

Regulation respecting Asbestos on Construction Projects and in Buildings and Repair Operations – made under the Occupational Health and Safety Act Ontario Regulation 654/85

Regulation respecting Arsenic – made under the Occupational Health and Safety Act Ontario Regulation 176/86 as amended by O.Reg. 23/87

Regulation for X-Ray Safety – made under the Occupational Health and Safety Act Ontario Regulation 623/86

Regulation respecting Oil and Gas – Offshore – made under the Occupational Health and Safety Act Ontario Regulation 633/86

Regulation respecting Diving – made under the Occupational Health and Safety Act Ontario Regulation 634/86

Regulation respecting Control of Exposure to Biological or Chemical Agents – made under the Occupational Health and Safety Act Ontario Regulation 654/86 as amended by O.Reg. 707/86

Regulation respecting Ethylene Oxide – made under the Occupational Health and Safety Act Ontario Regulation 146/87

Support Literature

An Occupational Health Nurse's Guide to the Preparation of a Policy and Procedure Manual

A Guide to the Occupational Health and Safety Act

A Guide for Joint Health and Safety Committees and Representatives in the Workplace

Designated Substances in the Workplace: A General Guide to the Regulations

Designated Substances in the Workplace: A Guide to the Lead Regulation

Designated Substances in the Workplace: A Guide to the Benzene Regulation

Designated Substances in the Workplace: A Guide to the Silica Regulation

Designated Substances in the Workplace: A Guide to the Mercury Regulation

Designated Substances in the Workplace: A Guide to the Asbestos Regulation for Construction Projects, Buildings and Repair Operations

Report on the Annual Meeting of the OMA Occupational Health Section, May 28, 1987

Summary

The Scientific Session of the annual meeting of the Ontario Medical Association's Occupational Health Section was held at the Inn on the Park in Toronto, Ontario. It consisted of four presentations, summarized herein.

Solvent Neurotoxicity

Dr. J. Mattsson from the Dow Chemical Company primarily selected Scandinavian background literature to discuss the neurotoxic potential of some organic solvents. The quantification of exposure to solvents is estimated partly from the frequency and character of acute symptoms. The diagnosis is based on air sampling records, the presence of chronic encephalopathy, which is primarily neuropsychiatric in nature, and by exclusion.

The epidemiology of Scandinavian solvent neurotoxicity is mostly historical. S. Hernberg evidently reviewed five studies dealing with solvent exposures in painters, varnishers, carpet layers and woodworkers. It was concluded that the relative risk of developing a psycho-organic syndrome from such exposures was about 1.5-2.0. Hernberg estimated that 0.5 per cent of an unexposed population has a neurasthenic syndrome. Based on this, out of 100,000 solvent workers, 500 would be neurasthenic by chance and 200-500 as a result of solvent exposures. The default diagnosis is that the syndrome is work related, whereby half to two-thirds of the cases diagnosed would be misclassified. Errebo-Knudsen and Olsen, in their paper 'Organic Solvents and Presenile Dementia (The Painter's Syndrome)', found that low IQ individuals preferentially selected the painting trade. Mauszlish *et al* found that painters performed better than controls on many tasks during the behavioural evaluation of workers exposed to mixtures of organic solvents. Many solvent workers diagnosed as having a toxic encephalopathy performed in the normal range, reflecting a significant number of false positives. Therefore, diagnostic uncertainty regarding the presence of a neurotoxic syndrome is large.

In differentiating between solvents that have clearly defined neurotoxic effects and those that do not, three questions must be answered affirmatively: (1) Does the substance produce a consistent pattern of neurological dysfunction in humans? (2) Can the entity be reproduced in animals? (3) Are there reproducible neural lesions in man or animals and do these account for the neurobehavioural dysfunction? The Danish list of solvents meeting the above criteria include chloromethane, n-hexane, methyl ethyl ketone, trichloroethylene, dichloromethane and toluene. Dr. Mattsson would also include carbon disulphide in the list.

The laboratory findings in evaluating the neurotoxicity of toluene and o-cresol were used as examples. Audiotory brain response (ABR) to tone pips in toluene-exposed rats is depressed, reflecting ototoxicity. Visual evoked response is also reduced. In assessing somatosensory evoked response, there is a smoothing of fine detail in the contralateral sensory cortex when the median nerve is stimulated.

The speaker concluded his presentation by stating that a generic neurotoxicity syndrome is weak, if it exists, and significant solvent exposures (high and prolonged) are required to produce it. Neurotoxic solvent do exist, and their neurotoxic effects are probably due to their metabolites. The neurotoxic potency of a solvent and the resulting syndrome are metabolite specific.

Psycho Neurological Assessments

Dr. R. Duke, a neurologist affiliated with McMaster University in Hamilton, Ontario, discussed his approach to assessing workers with suspected solvent neurotoxicity. Dr. Duke commenced his presentation by reviewing the principles of such neurotoxicity: (1) it is substance specific; (2) host factors are minor; (3) there is a strong dose-response relationship; and (4) the neurotoxicity is enhanced by 'innocent bystander' chemicals, e.g. ethanol decreases solvent metabolism.

In general, acute effects of neurotoxic solvents are intoxication/encephalopathy. Chronic effects involving the CNS are classified as cortical (organic affective syndrome, chronic encephalopathy) or cerebellar (e.g. toluene). Chronic PNS effects are the peripheral neuropathies (e.g. n-hexane).

Dr. Duke's approach to an individual case of suspected toxicity is (1) to assess the exposure, (2) to define any neurological deficit present, and (3) to exclude any alternative explanation. It is important to recognize

that half of all neuropathies are idiopathic. In assessing exposure, a focused history should be taken regarding work conditions, work habits, personal protective equipment, health complaints of workmates, exposure levels versus time, ancillary history (spouse) and site assessment. Ancillary tests include EEG, CT Scan, and EMG (nerve conduction, needle testing and motor unit counting of muscle fibres supplied by one anterior horn cell and its axon).

Neuropsychological testing usually evaluates intelligence , personality, reaction times, etc. The tests are highly standardized and reproducible, but are time consuming (three to 10 hours), expensive and demanding. Different neuropsychologists will conduct different test batteries depending on their diagnostic philosophies, whereby it is important to know the principles followed by the psychologist to whom the patient is referred. Test results involve absolute scores and patterns of scores, i.e. clusters of defects, e.g. verbal versus performance, which may reflect a focal versus generalized cerebral deficit. Malingerers tend to perform erratically.

In ending, Dr. Duke stated that most patients generally improve over time, but some are left with permanent neural deficits.

During the question and answer period for the first two presentations, Dr. Mattsson summarized the current situation in neurotoxicity as being in a 'mess', largely due, presumably, to the diagnostic uncertainty. Dr. Duke readily concurred.

Drugs and the Workplace

Dr. K. Fehr from the Addiction Research Foundation in Toronto, Ontario gave an overview of drugs that may be used non-medically in the workplace. Good epidemiological information on drug use in the workplace or in the general population is not currently available. Therefore, the scope of the problem and its trends are not really known with accuracy. However, it was stated that the problem in Canada is not of the same magnitude as it is in the United States. Some data are available on drug use in the schools: the peak incidence of inhalant abuse occurs in Grades 7 to 9; cannabis use is more prevalent in Grades 9 to 11.

There are three main categories of psychoactive drugs: (1) depressants/sedatives, e.g. alcohol, opiates, barbiturates, diazepam, OTC antihistamines; (2) stimulants, e.g. amphetamines, ritalin, anorexiants; and (3) hallucinogens, e.g. LSD.

The depressants cause poor psychomotor control and compromised cognition. As little as 15-20 mg% blood alcohol levels show early effects on divided attention tasks with resulting attention lapses. Impairments from cannabis use are longer in duration than previously suspected. It has been found that pilots' performances in flight simulators are still markedly affected even 14 hours after blood alcohol levels have returned to zero. Nicotine deprived individuals show poorer performances in visual attention and vigilance 90-120 minutes after last smoking a cigarette. Such findings have potentially significant implications for smoke-free workplaces.

Stimulants enhance arousal, sense of well-being and self-esteem. Amphetamines are still widely used by long-distance truck drivers and were prevalent in professional sports in the past. Ephedrine, phenylpropanolamine and caffeine mixtures are sold on the black market as dextro-amphetamines. T&Rs are crushed talwin and ritalin tablets injected intravenously. The combination may be 'pre-flagged' by being dissolved in blood prior to injection for a reported enhanced effect. Heavy stimulant users have increased absenteeism rates due to 'crashing' when the stimulants are discontinued after several days of continuous use. Depressant drugs are often used to 'come down' from the stimulants, which is manifested by psychomotor defects. Mood changes can cause interpersonal work problems.

Although recent alcohol use is reasonably easily detectable, the identification of other drug use is more difficult. Cocaine has a relatively short half-life in urine (two to three days), whereas cannabis metabolites may persist up to seven days, making the time of most recent use difficult to determine with accuracy.

The use of hallucinogens in the workplace was not discussed, but is not expected to be as common as that of depressant or stimulant usage.

Drug Screening in the Workplace

DR. R. Ligo from E.I. du Pont de Nemeurs in Wilmington, Delaware described the du Pont Substance Abuse Program, which consists of three balanced elements: (1) a treatment program; (2) an awareness program; and (3) a detection program. Worker health, safety and environmental quality are of primary importance. Substance abuse is recognized and treated as a disease.

The treatment/rehabilitation program utilizes company approved treatment centres. It involves voluntary entrance, follow-up testing and confidential procedures. It is well publicized and is non-penalty oriented.

In the awareness program, the du Pont or similar drug training seminar (four hours) is conducted for all employees. Reinforcement is provided by safety meetings, printed materials, video tapes and bulletin board postings.

A comprehensive detection program exists to ensure the safety of the workplace. Testing is performed at the time of pre-employment, 'for cause', at random, and for follow-up. Vendors and contractors at plant sites are also tested, and the requirement for such testing is part of the contract language. Search procedures are used at the entry gates, including sniffer dogs.

The communications aspect of the program covers program principles, conditions of employment, use of drugs or alcohol on company property and the finding of drugs or alcohol in the possession of an employee.

Proper program administration limits access to information and the extent of inquiries to maintain privacy. Supervisors are trained in detection, and personnel staff in administration, e.g. modification of contracts to include testing.

Testing procedures include a consent form, drug history, sound collection methods to avoid tampering, courier pick-up and a chain of custody to the lab. Excellent quality control is imperative to the program. A single lab is used for consistency of analysis. Lab inspections are carried out by an external consultant and standardized test specimens are submitted to assess the accuracy of results. Less than 10 per cent of all specimens are evidently positive, with cannabis and cocaine being the drugs most commonly detected.

During the question and answer period for the last two presentations, a member of the audience indicated that drug screening would not be productive in Toronto as long as there is only a paucity of treatment programs available. Also, such a program would not be cost effective due to the high lab analysis fees in Canada compared to the United States. The usefulness of testing at the time of pre-employment was questioned in view of the fact that such testing would become known in the community and potential employees would discontinue drug use sufficiently early to avoid detection. Information regarding drug half-lives is apparently freely available in such counter-culture publications as *High Times*.

R. Frith

Conference Report: Seminar on Recognition, Evaluation and Control of Odours

Summary

This report summarizes the fundamental and practical aspects of odour science, instrumentation and control technology originally presented at a seminar held in Chicago, April 14-15, 1987.

Introduction

This seminar was sponsored by the American Industrial Hygiene Association (AIHA) and presented by the Illinois Institute of Technology Research Institute (IITRI). It was attended by about 30 participants, predominantly hygienists, from across the United States. The purpose of the seminar was to introduce participants to the fundamentals of odour science through classroom lectures and discussion as well as through actual hands-on experience in determining odour threshold using the dynamic olfactometer and odour intensity using the butanol wheel.

The field of odour science has, until very recently, been driven by psychologists rather than by physical scientists. Hence, some of the terms used and the approaches taken are somewhat foreign to most hygienists. The attached glossary of terms will assist those less familiar with the terminology used in this field.

Odour Standards

In a recent survey of national, state and local ordinances approximately 10 per cent of some 600 inquiries indicated some form of current regulations respecting odour. The majority of existing regulations are based upon an odour nuisance concept similar to that in Ontario, which is an entirely subjective evaluation by either the complainant or the inspector responding to the complaint.

The possible types of quantitative odour regulations were outlined as follows:

- Source Chemical Standard – i.e. the emission rate of compounds will not exceed indicated levels.
- Source Sensory Standard – i.e. the maximum odour threshold shall not exceed a specified dilution factor.
- Ambient Odour Standard – i.e. the ambient odour intensity shall not exceed a specified level on the butanol wheel.

Each type of standard has advantages and limitations. The source standards measure odorant at the source and merely estimate community or receptor response based on worst case dispersion models. The ambient standards measure community response to the odour accurately, but have difficulty in establishing the source(s) and/or multiple source attribution. It was suggested to the participants that the science of odours seems to be heading in the direction of ambient odour standards.

Olfactory Senses

Human response to odours is a function of both the olfactory epithelium and the trigeminal nervous system of the nose. The olfactory epithelium, located in the superior nasal cavity, consists of tiny cilia that actually detect the odorant molecules by a mechanism that is not yet understood. The superior cavity is not in the direct air flow path from nose to trachea, and only a very few of the odorant molecules inhaled reach the cilia, largely by turbulence and eddy mixing. Hence the natural tendency to inhale deeply when smelling an odour or fragrance in order to increase turbulent air flow in the nasal cavity.

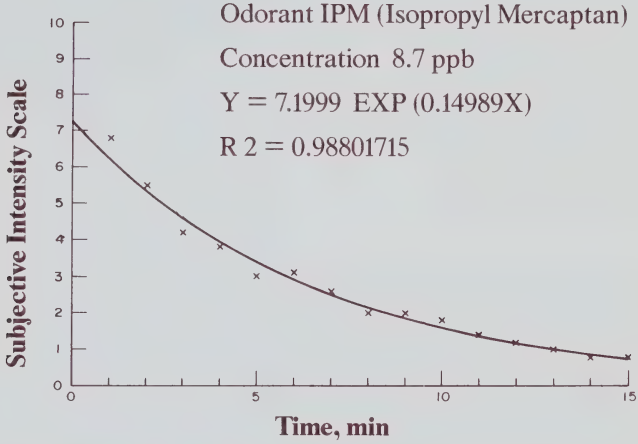
The trigeminal nervous system does not produce a cognitive recognition of odour but, rather, a sensory response such as hot/cool, stinging, prickling, etc. This system triggers physiological responses to odours, such as reduced breathing rate or holding one's breath, coughing, increased mucous flow, dilation of peripheral blood vessels, etc.

Human beings do not each have the same odour threshold, and even an individual's sensitivity varies from day to day, depending upon unknown factors. However, age, sex, and smoking history have apparently very little affect on people's odour sensitivity. Air temperature and humidity seem to have no real effect on odour threshold and sensory response, but may affect the odorant concentration by increasing vaporization rate or by causing accumulation due to atmospheric inversions.

Hydrogen sulphide was used as an example to illustrate the concepts of adaptation, recovery, fatigue and desensitization. The maximum response to any odorant is obtained with the first breath and the response is diminished with each subsequent breath due to adaptation. The adaptation process is very rapid (see Figure 1 – Adaptation to IPM @ 8.7 ppb). Recovery after removal of the odorant is also very rapid. Adaptation appears to occur for all known odorants. Adaptation is a psychophysi-

cal effect, and olfactory fatigue, a well known effect of H_2S, is a physiological effect where exposure to high concentrations deadens the sense of smell temporarily. Desensitization is the psychological process of ignoring or blocking out the malodorous sensations of the smell, as in sewage plants and rendering plants.

Figure 1 **Adaptation to IPM at 8.7 ppb**



IIT Research Institute

Instrumentation/Evaluation Fundamentals

Objective measurements are made with analytical instruments such as gas chromatography (GC), mass spectrometry (MS) and combinations of instruments (GC/MS and MS/MS) or GC analysis with the output split between the detector and a nose cup for sniffing each peak as it elutes. Preconcentration is necessary because a sensitivity of 100 ppt is usually necessary to detect most odorant chemicals reliably at their threshold.

Subjective measurements are made using odour panels to evaluate sensory response to various dilutions of the odorants. IITRI has developed a dynamic dilution olfactometer for measurement of odour thresholds and a butanol wheel for evaluation of odour intensity in terms of equivalent ppm of butanol.

The olfactometer continuously generates six separate dilutions of the same odour, each three times more dilute than the previous concentration (approx. 250:1 total dilution between highest and lowest concentration). Each

concentration is presented together with two blank air samples, and each panelist sniffs all three air streams for each of the six dilutions, starting with the most dilute. A forced choice experimental design is used in which each panelist is forced to choose one of the three air streams as containing the odorant even if unable to smell any difference. Results are then adjusted for the statistical probability of occasionally guessing correctly at levels below the true threshold. The individual's odour threshold is taken as the geometric mean of both the lowest concentration reliably identified and the next more dilute concentration. An odour panel consists of 10 panel members with a normal distribution of sensitive and insensitive noses. The ED_{50} concentration for the panel is taken as the geometric mean of the individual thresholds.

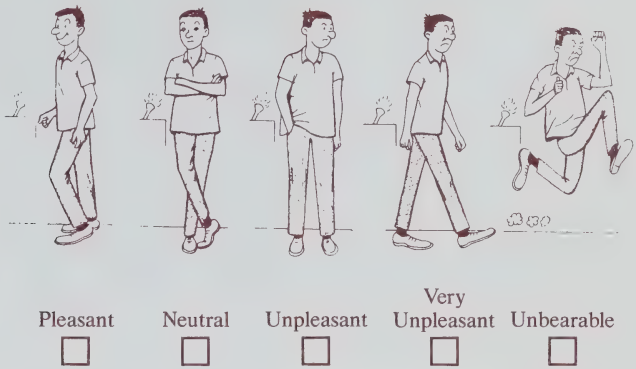
The butanol wheel is used to evaluate odour intensity by continuously providing eight different dilutions of butanol vapour from saturated vapour (approx. 1,500 ppm) to below the odour threshold of typically 2 to 3 ppm. It can be used to define an individual's odour detection sensitivity as sensitive, normal or low odour acuity. It is also used to evaluate the slope of the odour intensity-odorant concentration curve for any odorant by rating the intensity of the odorant at each dilution against butanol wheel concentrations of n-butanol vapour. Odorants with very low slope (i.e. 0.2) are persistent odorants because perceived odour intensity does not decrease significantly with dilution (e.g. H_2S and tobacco smoke). There is currently a controversy over this methodology because the ACGIH have recently reduced their TLV for n-butanol to a ceiling limit of 50 ppm, well below some of the higher concentrations generated by the butanol wheel.

Odour recognition thresholds are the concentrations at which half the test population can identify the odour and successfully describe it, based on a list of 146 odour description phrases. The recognition threshold is generally three to five times higher than the detection threshold.

Hedonic odour rating is a purely subjective reaction of the panelists to an odour's acceptability or pleasantness. Attempts to quantify the panelists' subjective reaction on an objective measurement scale have taken many forms, such as verbal description choices (pleasant, neutral, unpleasant), numeric scales (0 to 5, 0 to 7 or 0 to 10), line drawing with line length related to perception. One of the most original techniques is the cartoonist's depiction of reaction shown in Figure 2. Being a subjective rating, it is highly dependent upon the panelist's personal experience with that particular odour or similar odours.

Figure 2*

Cartoon Scale for Odour Testing.



Sampling Methodologies

Source sampling is typically done with a four-inch long by ¾-inch diameter stainless steel cartridge, packed with Tenax-GC (2.5 grams). Typically, two to four samples are collected at each source, using different volumes of between 0.2 and five litres and a flow rate not exceeding 0.5 LPM. The cartridges are then thermally desorbed at 250°C into a cryogenic trap, then flash desorbed into the GC for analysis and/or sniffing.

Whole air samples from sources are usually collected in a polyethylene Cube-tainer bottle, using a peristaltic pump and food-grade tygon tubing.

Ambient air samples are collected, either with the solid sorbant cartridge and volumes of at least 20 litres or with teflon bags. In order not to pass the ambient sample through a pump, the teflon bag is placed inside a rigid drum container, and the air is then pumped out of the drum to draw air into the bag, usually as quickly as possible (i.e. within 10 minutes). Bagged samples can then be connected directly to the olfactometer to determine odour detection threshold and dilution necessary to reach threshold.

*Reprinted from Clayton and Clayton, *Patty's Industrial Hygiene and Toxicology* with permission from John Wiley & Sons, New York, publishers.

Odour Transport Modelling

The objective of such modelling exercises is to estimate the downwind odour impact of a given source or sources and to estimate odour transport behaviour in the atmosphere. Two distinct approaches to transport modelling are currently in use by researchers in this field, and they can be classed as odorant modelling and odour modelling.

Odorant modelling uses the stack height and emission rate in combination with the classical air pollution dispersion modelling equations to predict downwind concentrations of the odorant from point sources. However, the IITRI researchers feel that this approach ignores the fact that odour impact is not directly related to odorant concentration because: (i) chemical reactions occur during plume transport; (ii) multiple sources of different odorants are not necessarily additive in determining final mixed odour intensity; (iii) odour intensity may decrease at a much slower rate than odorant concentration from some odorants due to persistance; and (iv) odour character often changes with distance as the different individual odorants drop below their separate odour thresholds.

Odour modelling is being developed by IITRI to supplant odorant modelling. This approach essentially uses a transformation technique to convert the odorant concentration at the source to an equivalent butanol concentration, which is then used in the traditional dispersion modelling equation to determine the dilution ratio from source to receptor. The dilution ratio thus obtained can be used in conjunction with the slope of the odour intensity/odorant concentration curve to estimate the equivalent butanol concentration at the receptor site. In two field trials conducted to date this technique has been superior to conventional odorant concentration modelling.

Odour Control Technology

Control technology is basically divided into two approaches: (a) process modification and (b) treatment of exhaust streams. Process modifications can take many forms depending upon the particular circumstances, but some general suggestions include;

- change raw materials specifications or sources
- use alternative processes
- change operating parameters of existing processes
- modify operating procedures such as housekeeping, receiving, discharging and charging
- reduce or eliminate fugitive emissions

Exhaust stream treatment can include the following:

- wet scrubbing (hypochlorite, permanganate, chlorine, etc.)
- thermal incineration (typically 1,800-2,000°F, 1 sec hold-up time)
- catalytic incineration (approx. 500°F, subject to poisoning)
- ozonation (requires long residence time to be efficient, 0_3 emissions?)
- adsorption (solid sorbants such as activated charcoal, Purafil, etc.)
- dilution (either by higher stack height or greater flow)
- masking (add odorant to cover, modify or counteract odour)

The general discussion of instructors and attendees who have had experience with the masking technique suggest that it may have limited utility for masking spills or transient odour problems and generally produces complaints and problems of its own after a short time when applied to continuous emission sources.

One cost analysis from actual field work done in 1972/73 illustrates the comparative costs of various treatment options for a rendering plant in the U.S. mid-west.

Objective: 99.9 per cent reduction in odour from a 25,000 CFM exhaust stack

Cost Analysis: $/hour per 1,000 ft^3 of gas treated

thermal incineration	- 0.83
catalytic incineration	- 0.83
packed-bed scrubber	- 0.28
spray scrubber	- 0.17

Three specific case histories concerning odour control at the following sites were also discussed.

Roofing Products Plant - control by adsorption of storage tank vent odours and wet scrubbing of process air and dilution ventilation air with pH-controlled, oxidizing solution.

Composting Facilities - control by enclosure of compost piles with negative pressure ventilation of building and scrubbing of ventilation air in an existing oxidizing scrubber, with increase of scrubber stack height.

Auto parts paint facility – control by study and reformulation of solvent system to remove isoamyl acetate, which chemically reacted to produce a specific odorant, plus better control and more frequent servicing of existing catalytic solvent incinerators.

Human Health and Odours

The general thrust of this presentation was that most materials have odour thresholds far below their Threshold Limit Values and most nuisance odours are generally not a significant toxic threat. The overall conclusion was that there is no quantitative evidence at the present time that directly relates health effects in the general community with typical malodorous sources such as sewage plants or rendering plants.

Conclusion

The course was worth attending for the general introduction it provided to the field of odour science. One would not expect to obtain 'expert' status after such a presentation, but it did provide a good working knowledge of the principles and a general understanding of possible control technologies.

The quality of the presentations was naturally variable from one presenter to another, but, in general, it was quite good. The afternoon practical session using the dynamic olfactometer and butanol wheel provided very valuable hands-on experience. The hand-out notes were very brief and there was no list of references available. Both of these comments were aired at the end of the conference and a bibliography was promised for each participant.

During the group discussion it was mentioned that the following three laboratories have had experience in the analysis of odour samples and can provide analysis of air samples for the identification of individual odorous chemicals.

IITRI, Chicago, Illinois.
RTI, Research Triangle Park, South Carolina.
College of Medicine and Dentistry at the
State University of New Jersey (Dr. Bernard Goldstein),
Piscataway, New Jersey.

The IITRI staff could act as useful resources for the hygiene service in future when consultation on odour problems is necessary. The techniques of odorant trapping and analysis, particularly by GC/sniff, could prove useful in identifying odour sources, especially where there

may be multiple sources and difficulty in identifying which is the major odour emissions source. The present odour restrictions incorporated in the CSA standard on Compressed Breathing Air have been shown by this course to be impossible to interpret and implement. If there is a need for an odour guideline within the standard, it should be based upon something similar to the butanol wheel generator, where the intensity of the odour could be quantified.

Appendix
Glossary of General Terms

Annoyance and Nuisance Laws
Annoyance involves a negative factor for the individual's comfort and well-being. From the medical view, annoyance does not involve pathogenic effects. In odour pollution litigation it is this effect that the common nuisance laws address.

Odorant
A chemical substance capable of stimulating the olfactory system.

Odours
A sensation caused by the stimulation of the olfactory system.

Olfactometer
A vapour dilution device for preparing and presenting odorants at selected concentrations to persons for olfactory evaluation, e.g. judgements of odour intensity.

Psychophysics
A branch of psychology concerned with sensory responses to physical and chemical stimuli.

Trigeminal Response
A sensation caused by the stimulation of the trigeminal nerve. This sensation is that of physical feeling, such as stinging or coolness. Because it is so closely associated with odour perception, the trigeminal response is sometimes perceived as part of the odour character of a substance.

Odour Threshold
The minimum concentration of an odorant that can be sensed through the olfactory system. In general it is determined by an odour panel, and the result is generally given with the statistic of the percentage of the panel responding positively; usually, this statistic is the median, i.e. 50 per cent level.

Two types of odour threshold are in common usage:

Detection Threshold
The odour threshold is based on positive responses to olfactory stimuli without requiring recognition of the odour.

Recognition Threshold
The odour threshold is based on positive responses and require recognition of the odour.

Threshold Value is, in general, the term used in reference to that attribute. However, two symbols have been used in certain contexts:

C_t is used for threshold concentration.
ED_{50} symbolizes the 'effective dose' at which, in particular, 50 per cent of panel members report 'reliable detection of the odour'. This term was used by the IITRI group in their development of threshold determination by forced choice and dynamic olfactometry. It is most commonly used by experimentalists who follow the IITRI methodology. (See also odour dilution ratios.)

Odour Intensity
The attribute of odour that has a scalar relationship to the concentration of the stimulus odorant.

Pervasiveness
The attribute of odour that pertains to the rate of change of odour intensity with change in odorant concentration, i.e. the slope of an intensity-concentration plot.

Hedonic Tone
The odour attribute pertaining to the relative pleasantness or unpleasantness of an odour. (Hedonic neutrality is included in this range.)

Odour Notes
Odour notes pertain to the unique olfactory sensations derived from specific chemical functional groups. They are subject to modifications by variations in molecular structure and substituents.

Odour Character
Odour character is the array of odour notes of the odour sensation that permits one to distinguish odours of different substances on the basis of experience. (Dravnieks)

Odour Descriptors
An odour descriptor is an adjective given to an odour note. Usually, it refers to an odour commonly experienced, e.g. floral, caramel, sewer odour.

Odour Profile
An odour profile is a plot of the frequency with which panel members assign individual descriptors in an array of them to applicability to a test odorant. (A method of odour profiling is in the final stages of development as an ASTM Standard Method.)

The FIDO of Annoyance Factors
In the odour sector of air pollution practice, the acronym FIDO is a mnemonic for four factors affecting the degree of annoyance from environmental odours. The four factors are as follows:

Frequency of odour episodes
Intensity of odours
Duration of odour episodes
Offensiveness of odours

G.A. Saunders

Regional Rehabilitation Program Pilot Projects in Ontario

Summary

The article describes a pilot project to treat injured workers in the hopes of obtaining an effective form of rehabilitation for soft tissue and back injuries.

The Workers' Compensation Board is planning to authorize a number of regional rehabilitation programs throughout the province for the treatment of injured workers with soft tissue and back injuries.

The concept of the pilot projects resulted from a review of the early admission program to the Downsview Rehabilitation Centre (DRC). It was our experience that most of those admitted under this program had received no satisfactory rehabilitation treatment prior to coming to DRC. It was then that we realized that an earlier program was required in the community to help these workers recover at an earlier time and, as a result, to recover more fully.

As a result of the DRC experience it was recognized that an early rehabilitation program for those injured workers with soft tissue injuries, including back injuries, should be considered. Treatment would commence as early as possible after the injury, limiting bed rest to a maximum of two or three days.

These 'pilot projects' will be provided by a select group of treating agencies, some in a hospital setting and others in a non-hospital setting. Some of these programs will treat only back injuries, and others will also include soft tissue injuries of the limbs.

The modern approach to treatment of these types of injuries will be utilized. The treatment will provide pain relief by physical modalities, early mobilization and an active exercise component.

Emphasis will be placed on the active participation by the individual in his or her own rehabilitation. The programs will vary from a half day to a full day, five days per week, and the duration will depend upon the progress of the patient but will usually be less than three or four weeks. Family practitioners, specialists and other treating agencies will be encouraged to provide early referral to these programs, certainly within eight or 10 weeks of the injury.

It is hoped that the early treatment will hasten the recovery of the injured worker. It is expected that many will be able to return to their previous employment.

An in-depth evaluation of these projects will be undertaken by the Workers' Compensation Board to determine their effectiveness in providing a timely and effective form of rehabilitation to injured workers in this province.

On May 1, 1987 two of these centres accepted referrals for the rehabilitation programs. These centres are:

1) Canadian Back Institute,
   12 Sheppard Avenue, 5th Floor,
   Toronto, Ontario
   M5H 3A1.

2) St. Joseph's Hospital,
50 Charlton Avenue East,
Hamilton, Ontario
L8N 4A6.

On June 1, 1987 one other centre accepted referrals to the rehabilitation programs. This centre is:

1) Henderson General Hospital,
71 Concession Street,
Hamilton, Ontario
L8V 1C3.

Also, on July 1, 1987, an additional two centres commenced – one in Thunder Bay and one in Hamilton. These are:

1) The Northwestern Ontario Orthopaedic and Rehabilitation Centre,
63 Carrie Street,
Thunder Bay, Ontario
P7A 4J2.

2) The Early Treatment Centre for Industrial Injuries,
Hamilton, Ontario.

Other pilot projects are in the planning process for Windsor, Sudbury, Ottawa and London.

The success of the program will be predicated on the support of treating-practitioners in the community in referring those injured workers who are suitable candidates for these rehabilitation programs. The pilot projects will be one year in duration, but we are expecting positive results.

Very early reports of those centres that have commenced treatment suggest that these programs are operating well and have the support of the local medical community.

R.I. Mitchell

Occupational Health Centre at Queen's University Fall 1987 Sessions Preliminary Notice

These short courses will be generally useful to all personnel with responsibility and/or interest in workplace health and safety. Our experience indicates that they are equally well-received by managers, workers and specialists.

1. Wed. October 14	WHMIS and Provincial 'Right to Know' Legislation
2. Tues. November 3	The Wrist and Back in Industry
3. Tues./Wed. November 10-11	SOLVENTS – Health and Safety
4. Wed. December 2	Strategies and Techniques in Noise Control
5. Thurs. December 3	Audiometry Refresher
6. Wed./Thurs./Fri. December 2-4	Industrial Audiometry and the Effective Hearing Conservation program.

All sessions will be held at the Donald Gordon Centre, Kingston, Ontario. For on-site accommodation call (613) 545-2221.

The fees (including registration, lecture materials, coffee, lunch, and social hour on first day) are:

One-day	$145.00
Two-day	$225.00
Three-day	$305.00

Registration in all sessions is limited.

Additional information will be mailed in August to those on our mailing list; for further information, please contact:

U.I. Bickis, M.Eng.
Senior Occupational Hygienist
Occupational Health Centre
Abramsky Hall – 2
Queen's University
Kingston, Ontario K7L 3N6
Phone (613) 545-2909
Fax (613) 545-6300

Pulmonary Function Testing in Industry

A three-day workshop for persons who perform forced expiratory spirometry, a lung function test required under several regulations, is offered on December 2-4, 1987 at the School for Continuing Studies, University of Toronto, 158 St. George Street, Toronto, Ontario M5S 1V8. Fee $325.00. The course includes one evening at the Ministry of Labour, Occupational Health Branch Chest Clinic.

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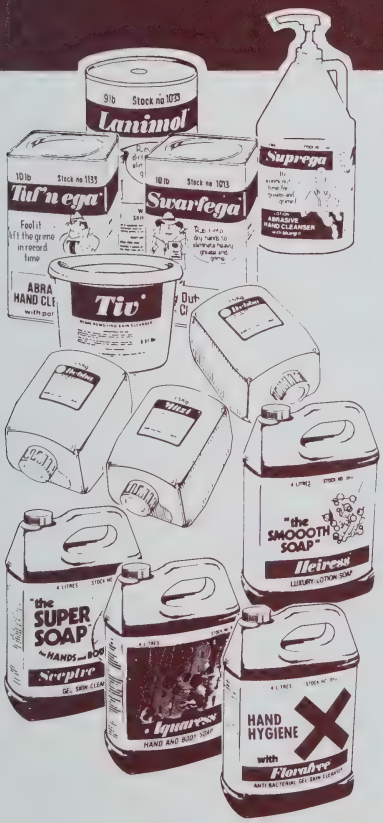

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Coming Events

October 6–8, 1987	1st International Symposium on Bio-Processing Safety Standard Guidelines and Practices to Insure Worker Safety in the Bio-Processing of Industrial Chemicals, Foods and Waste Products. WASHINGTON, D.C., U.S.A. For further information, contact: W.C. Hyer, Jr., Hytech Development, Princeton, N.J., U.S.A., 08543-2003, Phone (609) 896-2437.
October 10–12, 1987	Technical Seminar on Chemical Spills. TORONTO, CANADA. For further information, contact: M. Cloutier, Technology Development and Technical Services Branch, Environment Canada, Ottawa, Ontario, Canada, K1A 1C8.
October 13–16, 1987	Ontario Medical Association of Canada and Canadian Board of Occupational Medicine Annual Meetings. Westin Hotel, TORONTO, CANADA. For further information, contact: Dr. F.C. Mills, 1084 St. Anthony Road, London, Ontario, Canada, N6H 2P6. Phone: (519) 667-7533.
October 14–16, 1987	9th International Colloquium on the Prevention of Occupational Risks Due to Electricity. MADRID, SPAIN. For further information, contact: Berufsgenossenschaft der Feinmechanik und Electrotechnik, Gutav-Heinemmann-Uffer 130, D-500 Cologne 51, West Germany.
October 19–23, 1987	16th Annual Ontario Occupational Health Nurses Conference. OTTAWA, CANADA. For further information, contact: Barbara Taylor, 1116 Castle Hill Drive, Ottawa, Ontario, Canada, K2C 2A8. Phone (613) 725-4161.
November 2–5, 1987	Review of research on the biological effects from exposure to electric power transmission systems. For further information, contact: W/L Associates Ltd., Ste. #4, 120 W. Church Street, Frederick, MD. U.S.A., 21701, Phone (301) 663-1915.

March 8–10, 1988	First International Conference on the Global Impact of AIDS, LONDON, ENGLAND. For further information, contact: Emap Maclaren Exhibitions Ltd., P.O. Box 138, Token House, 79-81 High Street, Croydon, England, CR9 3SS.
April 10–17, 1988	Seventh International Congress of the International Radiation Protection Association, SYDNEY, AUSTRALIA. For further information, contact: IRPA Secretariat, GPO Box 2609, Sydney, NSW, Australia, 2001.
April 12–15, 1988	Annual British Occupational Hygiene Society Conference. NOTTINGHAM, ENGLAND. For further information, contact: BOHS, 1 St. Andrew's Place, Regent's Park, London, England, NW1 4LB
April 27–29, 1988	4th Symposium on Handling of Environmental and Biological Samples in Chromatography, BASLE, SWITZERLAND. For further information, contact: Professor R.W. Frei, Department of Analytical Chemistry, Free University, De Boelelaan 1083, 1081 HV Amsterdam, The Netherlands. Phone (020) 5485379.
July 11–15, 1988	Society of Occupational Medicine, Annual Provincial Meeting: New Technology – New Challenges. GUILDFORD, ENGLAND. For further information, contact: Dr. I.M. Dawson, Society of Occupational Medicine, 6 St. Andrews Place, Regents Park, London, England, NW1 4LB.
August 12–16, 1988	First Symposium on Biological Effects, Hazards and Protection from Non-Ionizing Radiation in Outdoor Applications. STOCKHOLM, SWEDEN. For further information, contact: NIRO 87, c/o KREAB Congrex, Box 5619, Stockholm, Sweden, S-114 86.
August 15–18, 1988	ICCEF 88. Third International Conference on the Combined Effects of Environmental Factors, FINLAND. For further information, contact: Chairman, Doc DR Olavi Manninen, ICCEF 88, Secretariat, c/o Dept. of Public Health, Medical Faculty, University of Tampere, P.O. Box 607, Tampere, Finland, SF-33101.

August 21–25, 1988	Noise '88 – The 5th International Congress on Noise as a Public Health Problem – STOCKHOLM, SWEDEN. For further information, contact: Noise '88, c/o Reso Congress Service, Stockholm, Sweden, S-113 92.
August 30– September 1, 1988	Inter-Noise '88. 17th International Conference on Noise Control Engineering, AVIGNON, FRANCE. For further information, contact: Inter-Noise '88, Secretariat, BP 23, Senlis Cedex, France, F 60302.
September 5–8, 1988	CIB Conference – Health Buildings '88. STOCKHOLM, SWEDEN. For further information, contact: The Swedish Council for Research, S:t Goransgatan 66, Stockholm, Sweden, S-112 33.
September 5–9, 1988	Fourth International Conference on Nickel Metabolism and Toxicology. ESPOO, FINLAND. For further information, contact: Fourth International Conference on Nickel Metabolism and Toxicology, c/o Institute of Occupational Health/ Ms Seija Toro, Topeliuksenkatu 41 a A, Helsinki, Finland, SF-00250. Phone: (+358 0) 474 71, Telex: 121394 tltx sf occuphealth, Telefax: 414634.
September 20–23, 1988	Second International Symposium on Ventilation for Contaminant Control, Ventilation '88, LONDON, ENGLAND. For further information, contact: British Occupational Hygiene Society, 1 St. Andrew's Place, Regent's Park, London, England, NW1 4LB.
October 5–8, 1988	ICOH Scientific Committee – Second International Workshop on Personal Computer and Data Banks in Occupational Health, PALMA DE MALLORCA, SPAIN. For further information, contact: Dr. Jose Sevillaa, Mutua Balear, c/. Obispo Campins 4, Palma de Mallorca, Balear Islands, Spain.

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ISSN 0705-9388

043526050